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Note on the measurements of α-particle energies with scintillation counters

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With 3 figures in the text

BROSER and KALLMANN[1, 2] have shown the possibility of determining α-particle energies with a scintillation counter. They used a large single crystal of cadmium sulphide in connection with a photo-multiplier. The scattering of the light from a microcrystalline screen makes it preferable to use a single crystal to reduce the pulse height straggling. The crystals of cadmium sulphide emit light with a maximum intensity near 8000 A. The RCA photo-multipliers (931-A, 1P21, and 1P28) are insensitive in this spectral region. Large single crystals of zinc sulphide phosphors which have more suitable fluorescence spectra are very difficult to prepare. Therefore we tried to use an ordinary fluorescent screen, Philips Metalix, in connection with a commercial RCA photo-multiplier. Organic phosphors have a poor light yield for α-particles[2], but can be obtained in large single crystals. We have also studied the scintillations from a thin transparent crystal of naphthalene.

A little piece of the Philips Metalix screen, about 2 mm × 2 mm, or a naphthalene crystal was fixed to the glass wall of the photo-multiplier. A concave mirror with 7.5 mm radius was placed behind the scintillator. α-particles from a polonium source passed through two slits of copper folium and struck the phosphor. The pulses from the photo-multiplier were amplified and counted by a Model 200 Pulse Counter.[3]

The distribution of the pulses was studied, mainly the influence of the following factors.

a) The instrumental straggling for scintillations from nearly monoenergetic α-particles striking the Philips Metalix screen.

b) Different α-energies on the Metalix screen and the naphthalene crystal.

α-particles with an energy of a few MeV striking the Philips Metalix gave about 1000 photo-electrons from the cathode of the multiplier. To investigate the instrumental straggling we measured the pulse distribution for different voltages on the photo-multiplier. α-particles from Po of 3.4 MeV energy (2.0 cm residual range[4]) impinged on the Metalix screen in connection with an RCA

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[1] I. BROSER and H. KALLMANN, Nature *163*, 20 (1949).

[2] H. KALLMANN, Phys. Rev. *75*, 623 (1949).

[3] W. A. HIGINBOTHAM, J. GALLAGHER, and M. SANDS, Rev. Sci. Inst. *18*, 706 (1947).

[4] M. S. LIVINGSTONE and H. A. BETHE, Rev. Mod. Phys. *9*, 266 (1937).

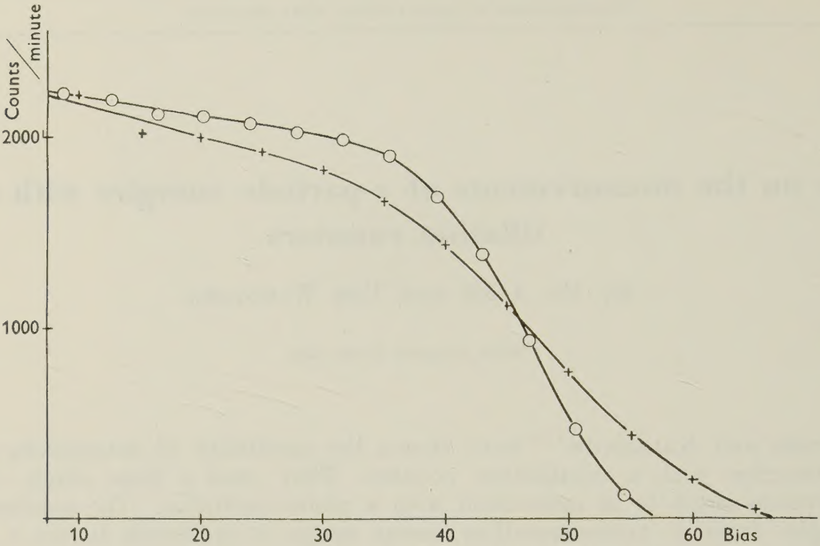

Fig. 1. Pulse Distributions for 3.4 MeV alphas on Philips Metalix, 1P28.

+ 67 volts per stage.
O 84 volts per stage.
Bias in different units.

1P28 tube. The shapes of the distributions for 67 and 84 volts per stage are given in figure 1. Increasing of the voltage to 100 volts per stage seems to give only a little further improvement.

The pulse distributions for different α-energies were studied with a Metalix screen on RCA 1P21 and 1P28. The photo-multipliers were operated at 84 volts per stage. The different α-energies were obtained by slowing down polonium-alphas in air. The energy-values are taken from the residual ranges.[1] The pulses were so great that no dark pulses could be detected. No back-ground was observed.

The duration of the flash made it necessary to use a rather long output RC which of course integrated the dark pulses.[2] This integration had apparently little importance in this case when the α-pulses were great and the counting rate was low. Our 1P28 had an extremely low dark current in comparison with 1P21 and an amplification comparable with that of the 1P21. The best results were obtained with this 1P28. The pulse distribution for two α-energies are given in figure 2. Rough estimations of α-particle energies of this magnitude can apparently be made with this apparatus.

Po α-particles on a naphthalene crystal gave about 15 photoelectrons from the cathode of the photo-multiplier. The dark pulses can no longer be neglected but must be subtracted (Figure 3). The statistical fluctuations and the other instrumental straggling cause a broad distribution but it seems possible to

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[1] See foot-note 4 on the preceding page.

[2] F.-H. Marshall, J. W. Coltman, and A. I. Bennet, Rev. Sci. Inst. *19*, 744 (1948).

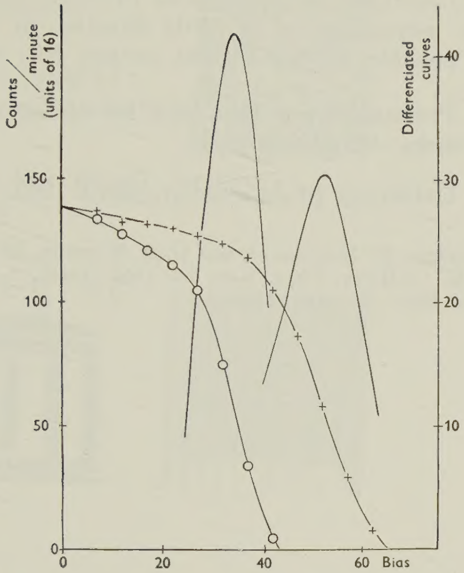

Fig. 2. Pulse Distributions for alphas on Philips Metalix, 1P28.

○ 2.0 MeV.
+ 3.4 MeV.

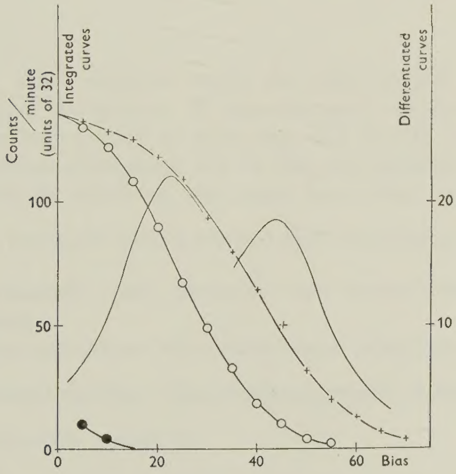

Fig. 3. Pulse Distributions for alphas on naphtalene, 1P28. Dark pulses subtracted.

○ 3.2 MeV.
+ 4.1 MeV.
● Dark pulses.

distinguish between α-particles of appreciable different energies. The organic scintillators have the advantage of a short duration of the light flash.[1, 2, 3] This fact makes it possible to use a short output RC, which allows a high counting rate.

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[1] I. BROSER, L. HERFORTH, H. KALLMANN, and U. M. MARTINS, ZS f. Naturf. *3 a*, 6 (1948).
[2] G. B. COLLINS and R. C. HOYT, Phys. Rev. *73*, 1259 (1948).
[3] G. B. COLLINS, Phys. Rev. *74*, 1543 (1948).

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